

EXHIBIT 2

Docket No. 117440-00005
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor:

Adrian BOYLE

Confirmation No.: 1088

Application No.: 14/436,869

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Examiner: Puneet S. Dhillon

For: IMPROVEMENTS IN AND RELATING TO
GATHERING RANGE AND DIMENSIONAL
INFORMATION FOR UNDERWATER
SURVEYS

Certificate of Transmission (37 C.F.R. §1.8(a))

I hereby certify that this correspondence is being filed via facsimile to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date set forth below.

February 2, 2018

By: /John J. Penny, Jr./

Date of Signature and Transmission

John J. Penny, Jr. – Reg. No. 36,984
Attorney for Applicant

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

**AMENDMENT AND RESPONSE TO FINAL OFFICE ACTION AND PETITION FOR
EXTENSION OF TIME**

Commissioner:

Applicant submits this paper in response to the Final Office Action dated August 4, 2017. A Request for Continued Examination (RCE) Transmittal is being filed concurrently herewith.

Applicant petitions to extend the time for response to the Final Office Action dated August 4, 2017, for 3 months, to and including February 5, 2018 (February 4, 2018 being a Sunday in the District of Columbia). The extension fee has been paid herewith.

In response to the Final Office Action dated August 4, 2017, Applicant respectfully requests entry of this Amendment, in which:

- **Amendments to the Claims** begin on page 2; and
- **Remarks** begin on page 6.

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AMENDMENTS TO THE CLAIMS

The Claim Listing below will replace all prior versions of the claims in the application:

Claim Listing

1. (Currently Amended) An underwater survey system for gathering range and 3D dimensional information of subsea objects, the system comprising

a camera configured to capture images of a subsea scene; and
one or more reference projection light sources configured to project one or more structured light beams

the camera configured to capture a sequence of images of each of a plurality of fields of view within the scene, where each of the plurality of fields of view of the scene is illuminated by one or more of the light sources, and wherein the camera and light sources are synchronized so that each time an image is acquired, a specific configuration of light source parameters and camera parameters is used;

the one or more reference projection light sources having a fixed distance from the camera and a fixed orientation in relation to the camera.

2. (Previously Presented) An underwater survey system as claimed in claim 1, wherein at least one of the one or more reference projection light sources comprise a laser.

3. (Previously Presented) An underwater survey system as claimed in claim 1, wherein at least one of the one or more reference projection light sources is adapted to:

project a straight line beam on a target,
project a point beam on a target,
project a beam of a set of parallel lines on a target, or
project a grid beam on a target.

4. (Previously Presented) An underwater survey system as claimed in claim 1, being configured to analyze the captured images to determine the optimal imaging or lighting parameters.

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5. (Previously Presented) An underwater survey system as claimed in claim 1, being configured to adjust imaging or lighting parameters to produce images optimized for machine vision.

6. (Previously Presented) An underwater survey system as claimed in claim 4, being configured to perform machine vision techniques to reduce the impact of floating particles in a scene.

7. (Previously Presented) An underwater survey system as claimed in claim 1, wherein at least one of the one or more structured light beams is configured to be parallel with the orientation of the camera.

8. (Previously Presented) An underwater survey system as claimed in claim 1, comprising a pair of reference projection light sources, each a fixed distance from the camera and a fixed orientation in relation to the camera.

9. (Previously Presented) An underwater survey system as claimed in claim 8, wherein the reference projection light sources are configured to project substantially identical structured light beams.

10. (Previously Presented) An underwater survey system as claimed in claim 8, wherein the reference projection light sources are each the same distance from the camera.

11. (Previously Presented) An underwater survey system as claimed in claim 8, wherein the reference projection light sources each have the same orientation in relation to the camera.

12. - 13. (Canceled).

14. (Previously Presented) An underwater survey system as claimed in claim 1, comprising a pair of cameras.

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15. (Currently Amended) A method for gathering range and 3D dimensional information of subsea objects in a system comprising a camera and one or more reference projection light sources, the method comprising the steps of:

the one or more reference projection light sources projecting one or more structured light beams onto an object; and

the camera capturing a sequence of images of each of a plurality of fields of view of the object having the one or more structured light beams projected thereon, where the object is illuminated by one or more of the light sources, wherein the camera and light sources are synchronized so that each time an image is acquired, a specific configuration of light source parameters and camera parameters is used.

16. (Previously Presented) A method as claimed in claim 15, wherein the system further comprises an image processor, and at least one of the one or more structured light beams is configured to be parallel to the orientation of the camera, where the steps of the method further include:

the image processor measuring, in the captured images, a horizontal distance from a vertical centerline of the image to the structured light beam;

comparing the measured horizontal distance to a known horizontal distance between a center of the lens and the structured light beam; and

deducing a range to the object based on a known magnification of the image caused by the lens.

17. (Previously Presented) A method as claimed in claim 15, wherein the system further comprises an illumination source, and the method comprises the additional steps of

the illumination source illuminating the object to be surveyed,

the camera capturing an image of the illuminated object; and

superimposing the two captured images to form an augmented output image.

18. (Previously Presented) An underwater survey system as claimed in claim 11, wherein the structured light beams are substantially parallel.

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19. (Previously Presented) An underwater survey system as claimed in claim 11, wherein the reference projection light sources are arranged such that the structured light beams intersect.

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REMARKS

Claims 1-11 and 15-19 are pending and stand rejected, of which Claims 1 and 15 are in independent form. Claims 1 and 15 are being amended herein. Reconsideration and withdrawal of the rejections are respectfully requested.

Amendments to the Claims

Claims 1 and 15 are being amended. Support for this amendment can be found in at least paragraph [0084] of the application as filed. No new matter is being added.

Claim Rejections - 35 USC § 103

Claims 1-11, 14, 18 and 19 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over “Imaging Systems for Advanced Underwater Vehicle,” Journal of Maritime Research: JMR, 1 April 2011, XP05093772 (“Bonin”), in view of U.S. Publication No. 2003/0058738 (“Erikson”) and further in view of U.S. Publication No. 2003/0215127 (“Stern”).

Claim 1 has been amended as follows:

“An underwater survey system for gathering range and 3D dimensional information of subsea objects, the system comprising
 a camera configured to capture images of a subsea scene; and
 one or more reference projection light sources configured to project one or more structured light beams,
 the camera configured to capture a sequence of images of each of a plurality of fields of view within the scene, where each of the plurality of fields of view of the scene is illuminated by one or more of the light sources, and wherein the camera and light sources are synchronized so that each time an image is acquired, a specific configuration of light source parameters and camera parameters is used;
 the one or more reference projection light sources having a fixed distance from the camera and a fixed orientation in relation to the camera.”

The conclusion of Bonin, on pages 81 and 82, describes the problems with imaging underwater and what can be achieved with different conventional lighting and laser sources. For example, Bonin discusses that polarization based techniques should be considered only when the vehicle is not moving. Furthermore, Bonin describes that the approach employed “*is able to significantly reduce the negative effects of backscatter in image formation at the cost of strongly*

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reducing the light intensity and, thus, at the cost of reducing the SNR. Although this technique may be useful to obtain clear images using a stationary camera, additional problems appear when mounting it onto an underwater mobile robot. On the one hand, the proposed method to estimate the algorithm parameters requires human intervention and, thus, are not suitable for autonomous operation. On the other hand, as the robot is continuously moving, it is not possible to guarantee that the two required images are obtained from the same position.” Thus, Bonin discusses the constraints of underwater imaging systems when mounted on ROVs or AUVs, and in fact teaches away from underwater imaging when the vehicle is moving.

What Bonin does not describe is the time that it takes using conventional imaging and image acquisition techniques, to acquire this data. Commercially, for an ROV or AUV, the time taken to acquire the data results in the associated ship spending time waiting for the acquisition. In the Bonin paper, as in ROVs, this is all done manually and over time. Bonin does not disclose a sequential imaging method as per the system of claim 1.

Amended claim 1 recites the camera and light sources are synchronized so that each time an image is acquired, a specific configuration of light source parameters and camera module parameters is used. This makes it possible to configure a plurality of light sources to acquire multiple inputs effectively at the time when the scene or imaged object is under a vehicle. When the vehicle is moving at speed, a minimum number of images for each type of structured light beam are acquired. These images can be acquired in rapid succession, automatically in a preprogrammed fashion. Each image yields different information about the object or scene. In this way, the position at which each image is acquired can be isolated, and a full spread of image types for each area can be obtained, as well as the measurements made. Bonin does not disclose or suggest that the camera and light sources are synchronized so that each time an image is acquired, a specific configuration of light source parameters and camera module parameters is used.

Using the system of claim 1, it is possible to facilitate short exposure, automated sequencing, multiple measurements from a moving vehicle of given object or scene from multiple fields of view, even when a vehicle is moving over that area, with the output being a correlated set of data with the object or scene.

For example, a vehicle having the system of claim 1 may be moving at a given speed in meters per second, typically 0.2 to 3 meters per second. A plurality of images of a scene may be

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captured and provide 100% coverage of an area with no spaces. There can be “oversampling,” i.e., 50% overlap means any given area is imaged twice. Structured light sources may be pulsed so that timing between consecutive images and the duration is predetermined in each sequence of images. As the speed is known (or determined from the images), the spatial relationship can also be known in this way. A sequential imaging method is provided whereby not only are a plurality of sequential images acquired but also additional sources of structured light, e.g. lasers, are also pulsed, with a known time relationship to each image in a sequence, and with a known time relationship to images captured using the other sources of light. This is due to each time an image is acquired, a specific configuration of light source parameters and camera parameters is used.

A second and other sources of light may be used to generate a 100% coverage, for example as a structured light profile, over an area to acquire 50 or 100 per second, resulting in a sequence of profiles separated spatially over the area. By this known time relationship when the images are acquired, the relationship between events in one set of data and a second set of data can be defined spatially, and therefore events and objects in the scenes can be correlated, either manually but particularly by machine vision.

In summary, the system of claim 1 facilitates lights to be pulsed rapidly for a fast moving vehicle, to allow these “rich” data sets to be collected “effectively simultaneously,” i.e., for the dwell time of the vehicle at a location, and multiple images of the scene can be captured. Laser data can be acquired between 100 microseconds and 10ms intervals. Bonin et al does not disclose or suggest all the features of amended claim 1.

Erikson discusses a real-time, three dimensional, acoustical camera and a real-time, range-gated, intensified, electro-optical camera having substantially overlapping fields of view for co-registered imaging of underwater objects at close ranges. The system is typically mounted in an unmanned underwater vehicle but may be used in other fixed or mobile configurations. However, Erikson discusses optical and *acoustical* images being co-registered in almost perfect alignment. Erikson does not disclose or suggest a camera configured to capture a sequence of images of each of a plurality of fields of view within the scene, where each of the plurality of fields of view of the scene is illuminated by one or more of the light sources, and wherein the camera and light sources are synchronized so that each time an image is acquired, a specific configuration of light source parameters and camera parameters is used, as recited in claim 1 of the present application.

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Stern discloses a system and method for simultaneously obtaining a plurality of images of an object or pattern from a plurality of different viewpoints. Stern is not concerned with a method and system for gathering range and 3D dimensional information of subsea objects. Moreover, Stern does not disclose a sequential imaging method as per the system of claim 1, whereby a camera is configured to capture a sequence of images of each of a plurality of fields of view within the scene, where each of the plurality of fields of view of the scene is illuminated by one or more of the light sources, and wherein the camera and light sources are synchronized so that each time an image is acquired, a specific configuration of light source parameters and camera parameters is used, as recited in claim 1 of the present application. In fact, Stern teaches away from a sequential imaging technique.

Erikson and Stern do not compensate for the above-noted deficiencies of Bonin, and thus claim 1 is novel and would not have been obvious over Bonin, Erikson and Stern.

Dependent claims 2-11, 14 and 18-19 are also patentable over Bonin, Erikson and Stern at least by virtue of their dependency on claim 1.

Claim 15 is rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Bonin in view of Erikson.

Claim 15 has been amended in a similar manner as claim 1 and thus would not have been obvious over Bonin and Erikson for at least the reasons provided above.

Claim 16 is rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Bonin in view of Erikson in view of Stern and U.S. Patent No. 5,673,082 (“Wells”) and further in view of U.S. Publication No. 2007/0237505 (“Takita”).

Claim 16 is dependent on claim 15 and thus is novel and would not have been obvious over Bonin, Erikson and Stern. Wells and Takita do not compensate for the above-noted deficiencies of Bonin, Erikson and Stern, and thus claim 16 also would not have been non-obvious.

Claim 17 is rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Bonin, in view of Erikson and further in view of “Assisted Teleoperation Through the Merging of Real and Virtual Images, Technical University of Catalonia (UPC)”: Pau Gargallo n. 5, 08028, Barcelona, Spain, Robotics Research, STAR 15 pp. 135-144, 2005 (“Casals”).

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Claim 17 is dependent on claim 15 and thus is novel and non-obvious over Bonin and Erikson. Casals does not compensate for the above-noted deficiencies of Bonin and Erikson, and thus claim 17 also would not have been obvious over Bonin and Erikson in view of Casals.

In view of the above, Applicant respectfully submits the Examiner to withdraw the rejections under 35 USC § 103.

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CONCLUSION

Applicant submits that all presently pending claims are in condition for allowance and respectfully requests allowance thereof. Applicant's amendment of the claims is done solely to expedite prosecution and does not constitute a concession that the claims are not allowable in their un-amended form. If the Examiner believes that a telephone conversation with Applicant's representative would expedite allowance of this application, the Examiner is invited to telephone the undersigned.

The Director is hereby authorized to charge any deficiency in the fees filed with this paper, asserted to be filed with this paper or which should have been filed with this paper to our Deposit Account No. 141449, under Order No. 117440-00005.

Respectfully submitted,

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By: /John J. Penny, Jr./
John J. Penny, Jr.
Registration No.: 36,984
NUTTER MCCLENNEN & FISH LLP
Seaport West
155 Seaport Boulevard
Boston, Massachusetts 02210-2604
(617) 439-2566
(617) 310-9566 (Fax)
Attorney for Applicant